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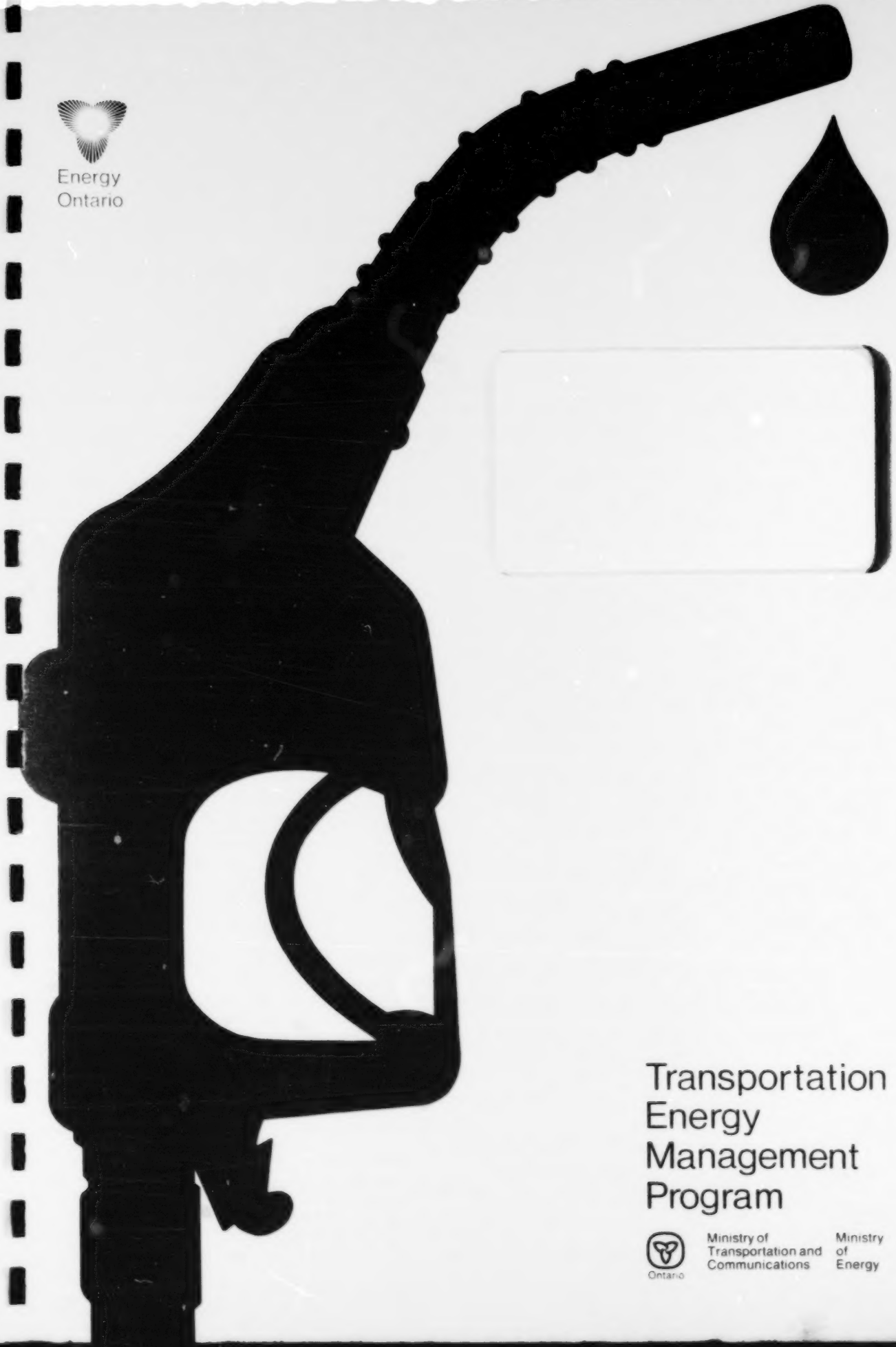

Transportation Energy Management Program

Ontario

Ministry of Transportation and Communications

Ministry of Energy

TEMP-87-02

TEMP Year-End Report
Part 2: Alternative Transportation Fuels
Fiscal Year 1986/87

TEMP-87-02

TEMP Year-End Report Part 2: Alternative Transportation Fuels Fiscal Year 1986/87

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The Transportation Energy Management Program (TEMP) is a joint program of the Ministry of Transportation and the Ministry of Energy (MENY) in which the Ministry of Transportation is responsible for the program delivery of the utilization aspects of transportation energy.

The report was prepared by the Ministry of Transportation's Automotive Technology and Systems Office to record TEMP's accomplishments during the past fiscal year.

Published by:
The Automotive Technology and Systems Office
The Transportation Technology and Energy Branch
Ontario Ministry of Transportation
Hon. Ed Fulton, Minister
D.G. Hobbs, Deputy Minister

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December 1987

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EXECUTIVE SUMMARY

The Alternative Transportation Fuels program is administered by the Automotive Technology and Systems Office of the Ministry of Transportation and is co-funded by the Ministry of Energy. This is a technical program with research, development, and demonstration components intended to facilitate the successful introduction and adoption of alternative fuels in the Ontario transportation sector.

The 1986/87 program consisted of 19 projects which were classified under the headings of propane, natural gas, alcohol fuels, diesel substitution, technology development, and fuels research. These projects were co-ordinated with the Alternative Energy Technology Development and Energy Technology Development sections of the Ministry of Energy.

The 1986/87 fiscal year was an active period for the Alternative Transportation Fuels (ATF) program. The large number of projects carried over from FY 85/86 provided the major workload of the program. The main emphasis in the program was on demonstration of natural gas and propane in the transit industry, development of hardware necessary for the successful utilization of alternative fuels, and research on new projects and technologies which present a significant potential to improve the effectiveness, efficiency and environmental acceptability of transportation means.

The alternative fuel demonstrations with transit properties progressed successfully, attracting wide publicity and producing hands-on experience with the utilization of alternative fuels in the transit environment. The Mississauga Transit natural gas vehicle (NGV) bus program was initiated, part of which was the conversion of an Ontario Bus Industries (OBI) thirty-foot bus to NGV operation by OBI and Fiba Canning, both Ontario companies.

The Hamilton Street Railway (HSR) NGV bus fleet was increased to five buses. HSR staff are highly satisfied with the performance of the NGV buses and are claiming fuelling cost savings of approximately $4000/bus. Due to this experience, HSR will explore the feasibility of expanding the NGV bus fleet to approximately one hundred buses. The OC Transpo propane bus demonstration produced sufficient experience and data to establish the technical feasibility of running transit buses on propane in the Ontario environment. This demonstration will be completed in March 1988 at which time OC Transpo is likely to decide on its position with respect to alternative fuels. The up-to-date results of these demonstrations were presented by Ministry of Transportation staff in a Roads and Transportation Association of Canada (RTAC) paper.

The major hardware development programs included the conversion of medium- and heavy-duty diesel engines to propane, natural gas and methanol operation. These projects were conducted at the Ontario Research Foundation (ORF) with the assistance of the Cummins Engine Co. and Ontario fuel suppliers. It is expected that fully operational, and engine dynamometer tested first- and second-generation alternative fuel prototype engines will be completed during FY 87/88. These engines will be road tested in truck and bus revenue operation during the 1987-1990 time frame, and are likely to offer significant environmental and economic benefits to Ontario users.

In a parallel development project, the Ministry of Transportation continued to work with Consumers Gas and Royal Military College (RMC) on the development of natural gas adsorbents which are intended to reduce gas storage pressures and make home-refuelling a more viable alternative to the current practice of station refuelling. The up-to-date results of this project were published by the Ministry of Transportation in an international conference paper. During this fiscal year, the Ministry of Transportation initiated a particulate trap development project with Engine Control Systems (ECS), an Ontario based manufacturer, and ORF. Particulate traps are expected to become necessary on buses and trucks in order to meet 1990s environmental air quality and emission standards. This project is designed to produce the best prototype ECS can manufacture with state-of-the-art trap materials and to assess its effectiveness by engine dynamometer testing.

The R&D activities of the program consisted of testing and evaluating a spectrum of equipment ranging from prototype units to in-use alternative fuel vehicles. The comparison of alternative fuel bus engines with their diesel counterparts by engine dynamometer testing was completed. This significant effort included engines from Detroit Diesel Allison (DDA), Iveco, and MAN running on diesel fuel, propane, natural gas, and methanol. The results were presented at two international conferences and will be submitted for publication as a Society of Automotive Engineers (SAE) paper.

The chassis dynamometer test program of natural gas conversion systems was completed and the results were published in an international conference paper. Similarly, the test program involving the Ontario in-use propane vehicle fleet was completed, and the results were presented at an international conference.

Within this fiscal year, the Ministry of Transportation also assessed prototype propane conversion systems with Inter City Liquid Gas, (ICG) and Centennial College, a prototype home compressor, and cold-starting and running characteristics of in-use propane and natural gas vehicles. These latter projects will be carried over into FY 87/88.

1/ ALTERNATIVE TRANSPORTATION FUELS

1.1/ Overview

The ATF program provides technical and scientific support to the Ontario government's goals of reduced dependence on gasoline and diesel fuel, efficient transportation, and industrial expansion.

The fiscal year 1986/87 program consisted of 19 projects, the majority of which were performed with direct participation from the private sector, who contributed financially and/or provided specialized equipment, services, and expertise. The remaining projects were carried out in consultation with private sector and government partners. These partners included equipment or vehicle manufacturers, fuel suppliers, vehicle fleet operators, government agencies, universities, and research institutions.

Three main alternative fuels were considered:
1/ propane
2/ natural gas
3/ methanol

Activities in support of these fuels fall broadly into one of three categories:
1/ applied research
2/ technology development or improvement
3/ demonstration and fleet testing

At present, the ATF program is giving a high priority to the development of gas engines for the heavy-duty sector, comprising trucks and buses. Larger fuel consumption, higher pollution levels, and higher diesel fuel prices make propane and natural gas very attractive for this sector. Unfortunately, there is next to no gas engine technology available to support the conversion of these vehicles. Consequently, the Ministry of Transportation Automotive Energy Section continued and expanded its efforts to overcome this technological barrier. Specifically, the OC Transpo propane, HSR natural gas, and Mississauga natural gas bus demonstrations were continued. An extensive bus engine comparative test program with six engines and four fuels was completed and published. The first generation Cummins Big-Cam propane engine was fully tested and demonstrated. Significant progress was achieved in the development of the second generation Cummins Big-Cam propane engine and the first generation Cummins L10 natural gas engines.

In parallel projects, the development of a particulate trap for bus applications was initiated with Engine Control Systems and ORF; the development of low-pressure natural gas adsorbents was continued at RMC with the assistance of Consumers Gas. The reliability and durability of test methanol vehicles were assessed with Ford and Shell, and a large number of in-house testing and evaluation projects were conducted with prototype and commercial equipment.

As indicated, the Alternative Energy Section activities covered a wide spectrum of topics and numerous projects, which are more thoroughly covered in the body of this report. However, individual project reports and papers should be consulted for full details of project description and results.

2/ PROPANE PROJECT REPORTS

2.1/ Technical Review and Assessment of Commercial Propane Conversion Systems (31553)

Project Objective

To review, in collaboration with equipment manufacturers and installers, the current propane conversion methods and equipment to identify potential areas of improvement. Tests will be conducted to confirm findings.

Activities

The test vehicle was converted to two different propane systems by ICG under the supervision of Centennial College. Once converted, the vehicle was tested at the Ministry of Transportation's dynamometer test facility.

Results and Achievements

The present state of conversion practices has been determined. Although several problem areas were identified, the feasibility of converting a fuel injected micro-processor controlled engine has been demonstrated. A preliminary report has been received from Centennial College with the final report to follow shortly.

Starting Date: April 1, 1986 **Completion Date:** March 31, 1987

Figure 2.1/ Fuel-injected 1986 Oldsmobile Calais Used to Test Two Different Propane Systems

3/ NATURAL GAS PROJECT REPORTS

3.1/ Evaluation of Compressed Natural Gas (CNG) Conversion Systems (31507)

Project Objective
To assist Ontario industry in developing superior natural gas conversion equipment.

Activities
Road testing was carried out on two Ford F-150 pickups operating on either gasoline or on an IMPCO natural gas system. As well, both vehicles were tested on the chassis dynamometer.

Results and Achievements
The road tests with both vehicles have been completed. The results indicate that the relative efficiency of the natural gas vehicle improves with respect to the gasoline vehicle efficiency as the ambient temperature decreases. Correlations between fuel consumption and ambient conditions such as humidity and atmospheric pressure were not evident.

Starting Date: April 1, 1986 **Completion Date:** March 31, 1987

3.2/ In-Use Evaluation of NG Home Compressors (31520)

Project Objective

To assess and demonstrate the technical and economic feasibility of CNG home refuelling with a commercially available small compressor.

Activities

The compressor has been successfully operated and used to refuel our natural gas test vehicle, and others, on a regular basis.

Results and Achievements

The technical feasibility of operating the compressor has been demonstrated. As well, the feasibility of operating within the present framework of Ontario's regulatory bodies for the gas and electrical industries has been determined. A report will be written when sufficient compressor operating time has been accumulated. The report will investigate both the technical and economic feasibility of the CNG Home Compressor.

Starting Date: April 1, 1985 **Completion Date:** March 31, 1988

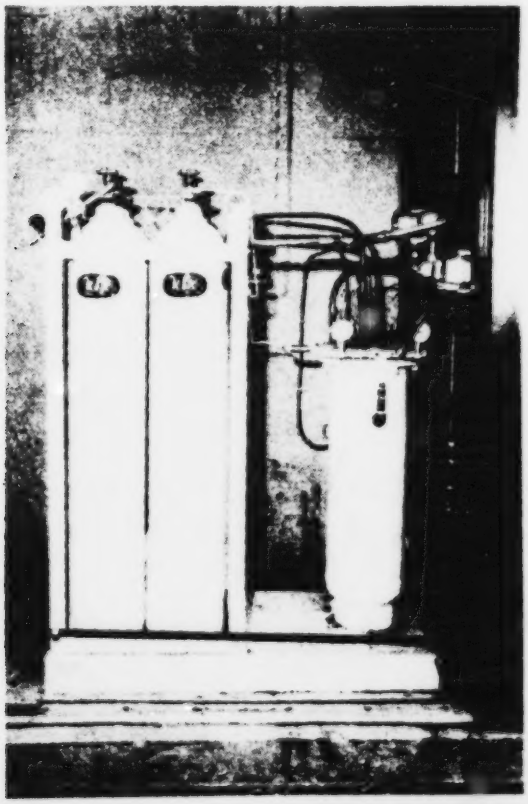

Figure 3.2/ Home compressor Being Used to Fill One of MTC's Natural Gas Powered Trucks

3.3/ Assessment of Cold-Start Performance of Propane/NG Vehicles (31563)

Project Objectives

To assist industry in identifying the causes of and solutions to widely reported vehicle startability problems with propane and natural gas vehicles.

Activities

The test vehicle was completely instrumented, then tested on the chassis dynamometer after a cold-soak period in the refrigerated storage trailer.

Results and Achievements

Cold driveability problems could not be simulated during the test program. Due to increasing warm weather, appropriate testing at colder temperatures could not be done. The project was therefore temporarily put on hold for completion in the winter of 87/88.

Starting Date: April 1, 1986 **Completion Date:** March 31, 1988

4/ ALCOHOL FUELS PROJECT REPORTS

4.1/ MTC/SUNCOR/Alberta Gas Chemicals (AGC) Methanol-Gasoline Blend Fleet Demonstration (31503)

Project Objective

To evaluate the acceptability of methanol/gasoline blends containing ethanol as co-solvent with respect to driveability, water tolerance, fuel consumption, emissions and component durability in the ministry's vehicle fleet.

Activities

Project suspended, pending agreement with the Motor Vehicles Manufacturers' Association (MVMA) on joint program.

Results and Achievements

Starting Date: April 1, 1983 **Completion Date:** March 31, 1987

5/ DIESEL SUBSTITUTION PROJECT REPORTS

5.1/ OC Transpo Propane Bus Demonstration (31500)

Project Objective
To demonstrate the feasibility and economics of operating a fleet of propane powered transit buses. Obtain information on reliability, operating costs and public acceptance.

Activities
Operation of the propane buses through the winter was very successful. Propane bus availability continued to exceed 80% with very few operational problems experienced.

Investigations have been initiated on an improved propane mixer and engine speed governor. Two companies with expertise in this area were contacted to look into the development of the new system. Installation of the proposed equipment would provide improved mixture control and better protect the engine against overspeed, than the existing system.

Results and Achievements
The propane bus demonstration program has been extended to March 31st, 1988. The fleet of propane buses will be maintained at its current level of nine until that time. Fuel consumption, maintenance and reliability data will continue to be collected and reported.

Starting Date: April 1, 1984 **Completion Date:** March 31, 1988

5.2/ Hamilton Street Railway (HSR) Natural Gas Bus Demonstration, Phase 2 (31517)

Project Objectives
To demonstrate the feasibility and economics of operating a fleet of natural gas powered transit buses. Obtain information on reliability, operating costs and public acceptance.

Activities
Five buses have been converted to natural gas. Four buses have been in revenue service for several months with no major problems. A sixth engine has undergone extensive optimization at the Ontario Research Foundation and will be installed in a sixth bus.

Results and Achievements
Four buses have operated reliably in revenue service. Two more will be added to the fleet in the coming months. Public acceptance has been

excellent and all buses are being fitted with power steering assist units to reduce driver steering effort.

Starting Date: April 1, 1984 **Completion Date:** March 31, 1988

5.3/ Inter City Gas (ICG) Propane Truck Demonstration (31551)

Project Objectives

To equip two class eight trucks with second generation Cummins propane engines. These trucks will be used by ICG to demonstrate the utility of propane to the trucking industry and to acquire operating data.

Activities

A demonstration program truck has been assembled using the first-generation propane engine. This truck received much public exposure across the country, in truck shows and in the press. Response to the program by the public continues to be very positive. Plans have been made to continue showing the vehicle through the summer of 1987. A new second-generation engine will be built and installed into a second vehicle.

Figure 5.3/ Western Star Class Eight Tractor Equipped with a Cummins Engine Powered by Propane

Results and Achievements
The proposed piston design for the new engine (produced by the Ontario Research Foundation) was approved by Cummins Engine Company, and has been sent to the piston manufacturer.

Engine dynamometer development work has been delayed due to late arrival of engine parts. Engine development is expected to commence in May 1987 and should be completed by the end of June 1987. Once completed this second generation engine will be installed in a class eight tractor, owned by ICG Liquid Gas. This tractor will then be entered into line-haul service as part of ICG's fleet.

After the line-haul tractor is completed, the demonstration tractor will have its engine upgraded to second generation specifications. This tractor will then be available for fleet demonstration by prospective customers of ICG.

Starting Date: April 1, 1986 **Completion Date:** March 31, 1988

5.4/ Conversion of L10 Medium-Duty Diesel Engine to NG (31559)

Project Objective
To develop a reliable medium-duty natural gas engine to displace some of the diesel fuel used by medium-duty trucks and buses.

Activities
Piston, camshaft and compression ratio designs have been selected and parts procured. Baseline testing of the diesel L10 has been completed. Engine build-up is continuing and engine development activities will proceed thereafter.

Results and Achievements
Baseline diesel L10 testing has been completed. Natural gas engine build-up is under way.

Starting Date: April 1, 1986 **Completion Date:** March 31, 1988

5.5/ Optimization of IVECO Natural Gas Engine (31577)

Project Objective
To determine the optimum operating specifications and to improve reliability of the IVECO natural gas bus engine.

Activities
A lean-burn optimum ignition strategy has been implemented and tested. The revised engine exhibited improved efficiency and reduced nitrogen oxides emissions. The engine will now be shipped to Hamilton Street Railway for installation in a bus and subsequent revenue service.

Results and Achievements
A 3% improvement in energy efficiency was achieved by the revised fuel/ignition system. Nitrogen oxides emissions were reduced as well. The engine is now ready for field trials at HSR.

Starting Date: April 1, 1986 **Completion Date:** March 31, 1988

5.6/ Mississauga Transit Natural Gas Bus Demonstration (31580)

Project Objective
To demonstrate the practicality of operating transit buses on natural gas by using a North American engine; to obtain information on efficiency, reliability, economics, and public acceptance.

Activities
An ORION (OBI) 30-foot bus has been modified to accept a GM 454 V8 (NGV) engine and NGV fuel system components. The bus has operated successfully on natural gas and is ready for revenue service.

Results and Achievements
The bus is now complete and ready for public revenue service. Daily operation will be closely monitored and fuel use data collected and analyzed.

Starting Date: April 1, 1986 **Completion Date:** March 31, 1988

6/ TECHNOLOGY DEVELOPMENT PROJECT REPORTS

6.1/ Transporter Development Contract, Phase 2 (31512)

Project Objective
To continue development of the innovative transporter system in order to establish its potential in the marketplace.

Activities
The Urban Transportation Development Corporation (UTDC) continues to issue task reports which were reviewed. These were not completed on schedule and an extension was granted to June 30, 1986.

Further delays were experienced and the final draft report was not received until October 1st, 1986. This was returned to UTDC with suggestions for changes and additions. The final report was issued on February 27, 1987 and is under review.

Results and Achievements
Final report has been issued but not reviewed.

Starting Date: April 1, 1985 **Completion Date:** March 31, 1987

6.2/ Aerodynamic Devices for Police Cruisers, Phase 2 (31519)

Project Objective
To develop and demonstrate devices which reduce aerodynamic drag on police cruisers equipped with light-bars.

Activities
The prototype light-bar was refined to increase stiffness and improve the strength and rigidity of the mounting hardware. The Ontario Provincial Police (OPP) installed the equipment on a Ford police vehicle, which was then commissioned in the Barrie OPP detachment for an assessment of the operational suitability of the unit. This assessment is expected to last six to eight weeks.

Results and Achievements
The prototype light-bar was fully assessed and was found to have significant merit relative to presently used units.

Starting Date: April 1, 1985 **Completion Date:** July 31, 1987

Figure 6.2/ OPP Cruiser Equipped with the Prototype Light-bar

7/ RESEARCH AND DEVELOPMENT PROJECT REPORTS

7.1/ Development and Testing of Natural Gas Adsorbents (31509)

Project Objective
To find, develop, and test new carbon adsorbents that have adequate capacity for compressed natural gas and are less expensive than the ones so far identified.

Activities
One litre quantities of three-inch disk samples of optimum SARAN/AX21 composition have been prepared and cyclic fill/empty testing is half complete. End of F/Y report received.

Results and Achievements
It has been proved that previously identified optimum concentrations, 2/3 AX21 1/3 SARAN carbon, has highest delivery volume after multiple cycling. Now set to manufacture 100 kg when furnace is ready.

Starting Date: April 1, 1985 **Completion Date:** August 31, 1987

7.2/ Ford-Shell Methanol Vehicle Demonstration (31511)

Project Objective
To determine the life time durability of factory supplied methanol vehicles in fleet operations with specially developed oil formulations.

Activities
Interim report on first year's work received. Methanol vehicle has been subjected to mileage accumulation using specially formulated oils. Regular analyses of used oil quality have been carried out to monitor wear metals. Results are being compared to parallel evaluation of two similar vehicles running on gasoline.

Results and Achievements
Methanol vehicles have achieved 16 000 km since last teardown and measurement, and gasoline vehicles 25 000 km. Indications, based on used oil analysis for trace wear metals, are that increased bearing and ring wear are being experienced with methanol while cam wear is about the same as gasoline.

Starting Date: April 1, 1986 **Completion Date:** March 31, 1988

7.3/ Evaluation of Ford Multifuel Automobiles (31571)

Project Objectives
To determine the performance of a factory supplied flexible fuelled vehicle on various mixtures of methanol and gasoline, with respect to fuel consumption, emissions, equivalence ratio and road driveability.

Activities
Aldehyde sampling system installed in dynamometer facility. Vehicle not delivered by end of F/Y. Fuel mixtures delivered and sent for analysis.

Results and Achievements
Vehicle evaluation ready to proceed when delivered.

Starting Date: April 1, 1986 **Completion Date:** March 31, 1988

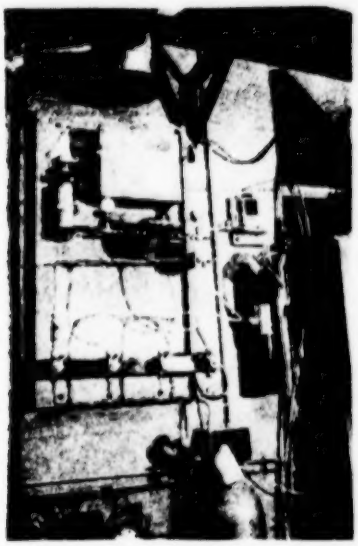

Figure 7.3/ Aldehyde Sampling Apparatus Installed in MTC's Chassis Dynamometer Facility

7.4/ Development of Particulate Traps for Diesel Trucks and Buses (31574)

Project Objective
To develop a diesel particulate trap and associated regenerating system capable of being installed on trucks and buses.

Activities
Trap design has been decided and sub-consultant selected for supply of trap and burner system.

Exhaust temperatures have been monitored on operating bus to provide input for design.

Results and Achievements
The first stage of the project has been completed and an Ontario supplier has been found to design and construct a trap prototype. A status report has been received.

Starting Date: April 1, 1986 **Completion Date:** March 31, 1988

7.5/ Development and Testing of Large Methanol Engines (31579)

Project Objective
To advance the medium- and heavy-duty methanol engine technology in co-operation with the Cummins Engine Co.

Activities
An L10 diesel engine has been converted to methanol use. The engine has been operated on a methanol/cetane improved mixture. Cummins Engine Company is continuing engine durability tests in the United States. Modified components will be shipped to ORF for use in the next phase of the project.

Results and Achievements
L10 diesel baseline testing is complete. The first generation methanol engine has successfully operated on cetane-improved methanol. Further development activities will commence shortly.

Starting Date: November 1, 1986 **Completion Date:** March 31, 1988

7.6/ Vehicle Performance Simulation (HEVSIM) (31581)

Project Objective
To determine efficiency of engines and vehicles used in demonstration programs on selected routes by computer simulation.

Activities
The original HEVSIM computer tape has been obtained, ready for use on the Ministration of Transportation IBM mainframe. The HEVSIM program remains on file at the University of Toronto ready for use when required.

Results and Achievements

The basis for a Ministry of Transportation in-house engine simulation program is in place. Further development of the program as well as vehicle component data acquisition activities continue.

Starting Date: April 1, 1986 **Completion Date:** March 31, 1988

8/ AUTOMOTIVE ENERGY ALLOCATIONS AND EXPENDITURES

8.1/ Introduction

The following pages summarize the funding allocations and expenditures for the Automotive Energy Section of the Transportation Energy Management program for FY 1986/87. The majority of the funding is that portion allocated by the Ministry of Energy (MENY) for direct operating expenditures, including consultant and university services, purchase of goods and equipment, and the direction of seminars. The tables on the following pages show the initial Ministry of Energy allocation as well as the final, actual expenditure.

The Ministry of Transportation's expenditure includes staff resources, data processing, travel and administrative costs. The tables do not include the Ministry of Transportation expenditures by offices other than Automotive Technology and Systems Office, even in cases where other offices incurred cost working on, or in support of, automotive energy projects.

Table 1 provides a general overview, while Tables 2 to 7 detail allocations and expenditures by project. The data presented in these tables have not been audited but are considered to be accurate.

8.2/ Financial Summaries

Table 1/ Alternative Transportation Fuels

Project Title	MENY Alloc	MENY Final Expenditure	MINISTRY OF TRANSPORTATION Final Expenditure
Transportation Energy Technology			
Propane	20.0	20.5	4.9
Natural Gas	27.1	22.4	24.3
Alcohol Fuels	80.0	37.1	24.9
Diesel Sub.	522.0	423.8	47.7
Technology Development	11.0	11.2	30.1
Research and Development	249.0	136.9	26.7
TOTAL	909.1	651.9	158.6

Table 2/ Propane

Project Number	Project Name	MENY Alloc.	MENY Final Expenditure	MINISTRY OF TRANSPORTATION Final Expenditure
31553	Technical Review and Assessment of Commercial Propane Conversion	20.0	20.5	4.9
TOTAL		20.0	20.5	4.9

Table 3/ Natural Gas

Project Number	Project Name	MENY Alloc.	MENY Final Expenditure	MINISTRY OF TRANSPORTATION Final Expenditure
31507	Evaluation of CNG Conversion Systems	10.0	8.6	10.1
31520	Evaluation of Home Compressors	2.0	2.4	11.9
31545	NGV School Bus Engine Development	0.1	0.0	0.0
31563	Assessment of Cold-Start Performance of Propane/NG Vehicles	15.0	11.4	2.3
TOTAL		27.1	22.4	24.3

Table 4/ Alcohol Fuels

Project Number	Project Name	MENY Alloc.	MENY Final Expenditure	MINISTRY OF TRANSPORTATION Final Expenditure
31503	MTC - Suncor Methanol Fleet Demo	30.0	36.1	24.7
31568	Methanol Bus Demo	50.0	1.0	0.2
TOTAL		80.0	37.1	24.9

Table 5/ Diesel Substitution

Project Number	Project Name	MENY Alloc.	MENY Final Expenditure	MINISTRY OF TRANSPORTATION Final Expenditure
31500	OC Transpo Propane Bus Demonstration	63.0	77.5	14.0
31517	HSR Natural Gas Bus Demo, Phase II	65.0	65.0	11.7
31551	ICG Propane Truck Demonstration	119.0	119.7	11.4
31559	Conversion Medium-Duty Diesel to Natural Gas	75.0	76.7	7.1
31560	Natural Gas Conversion 8.2 L Detroit Diesel	100.0	0.0	0.3
31564	Assessment NG/Diesel Fuel Conversions	40.0	0.0	0.2
31577	Optimization IVECO Propane and NG Engines	60.0	84.9	1.1
31580	Mississauga Transit NG Bus Demonstration	0.0	0.0	1.9
TOTAL		522.0	423.8	47.7

Table 6/ Technology Development

Project Number	Project Name	MENY Alloc.	MENY Final Expenditure	MINISTRY OF TRANSPORTATION Final Expenditure
31512	UTDC Transporter	11.0	11.2	21.4
31519	Aerodynamic Devices for Police Cruisers	0.0	0.0	8.7
TOTAL		11.0	11.2	30.1

Table 7/ Research and Development

Project Number	Project Name	MENY Alloc.	MENY Final Expenditure	MINISTRY OF TRANSPORTATION Final Expenditure
31509	CNG Adsorption Storage Materials Development	40.0	35.9	7.4
31511	Ford-Shell Methanol Vehicle Demonstration	27.0	27.8	4.9
31513	Methanol Cold-Start Performance, Phase II	20.0	0.4	2.4
31571	Evaluation of Ford Multifuel Vehicles	10.0	10.1	3.1
31573	Evaluation of Fuel System Compatibility to Alcohol	27.0	0.0	0.0
31574	Particulate Traps for Diesel Trucks and Buses	50.0	19.3	4.5
31579	Development of Large Methanol Engines	75.0	43.4	1.3
31581	Vehicle Performance Simulation	0.0	0.0	3.1
Total		249.0	136.9	26.7